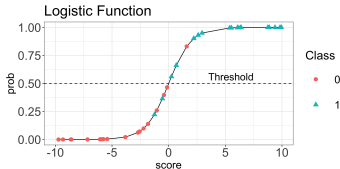


Introduction to Machine Learning

Supervised Classification: In a Nutshell

Learning goals

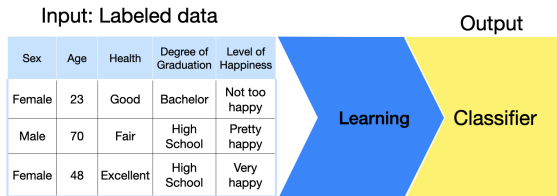
- Understand basic concept of classifiers
- Know concepts of probabilistic and scoring classifier
- Know distinction between discriminant and generative approach
- Understand ideas of logistic regression and Naive Bayes



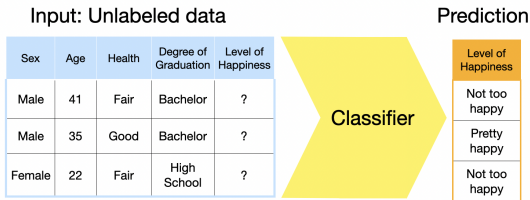
CLASSIFICATION TASKS

- Learn function that assigns categorical class labels to observations
- Each observation belongs to exactly one class
- The task can contain two (binary) or multiple (multi-class) classes

Training

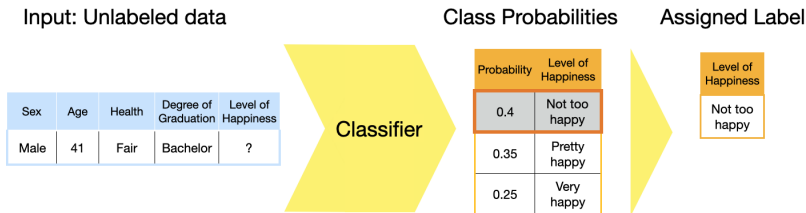


Prediction



BASIC DEFINITIONS

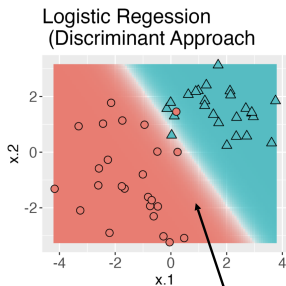
- For every observation a model outputs the probability (probabilistic classifier) or score (scoring classifier) of each class
- In the multi-class case, the class label is usually assigned by choosing the class with the maximum score or probability
- In the binary case, a class label is assigned by choosing the class whose probability or score exceeds a threshold value c



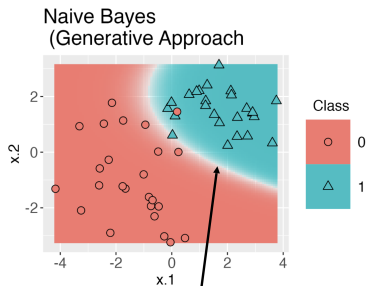
BASIC DEFINITIONS

Two fundamental approaches exist to construct a classifier:

- **Discriminant approach** asks “What is the best prediction for the class given these data?” (uses loss functions and empirical risk minimization)
- **Generative approach** asks “Which class tends to have data like these?” (models the feature distributions in each class separately)



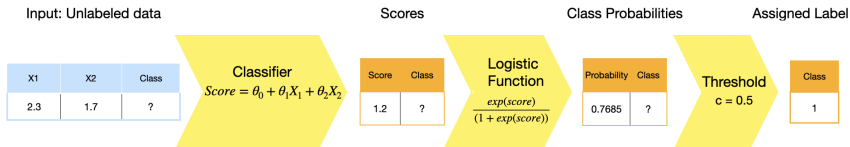
Decision Region: Region where all observations are assigned to the same class.



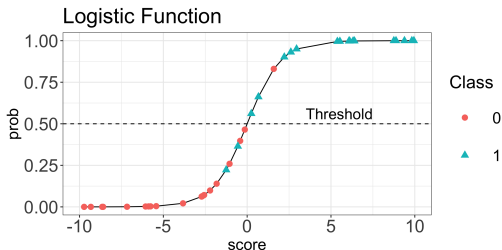
Decision Boundary: Points where all classes have the same probability/score.

LOGISTIC REGRESSION

- Logistic regression is a **discriminant approach** for binary classification. It turns scores into probabilities with the logistic function.
- We just need to compute the probability for **one** class (usually class 1).
- If the probability exceeds a threshold value **c** \Rightarrow class 1 is predicted.

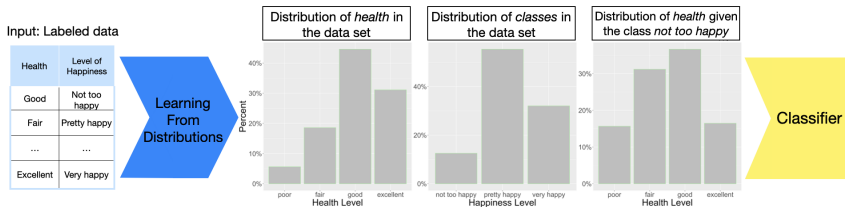


The logistic function puts all scores in order along an s-shaped line.



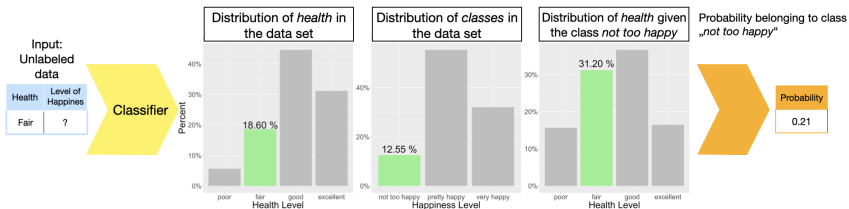
NAIVE BAYES

- Naive Bayes is a **generative multi-class approach**. It computes the class probability for each class based on the training data.
- It considers the data distribution on three different levels:
 - Marginal distributions $\mathbb{P}(X)$ of each feature (in the entire data set)
 - Conditional distributions $\mathbb{P}(X|Y)$ of each feature in each class
 - Marginal distribution $\mathbb{P}(Y)$ of classes (in the entire data set)



NAIVE BAYES

Example: Class probability of “not too happy” given health = “fair”:



Naive Bayes Classifier

Class probability given the data

